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Lag Responses in Mood Reports to Changes in the Weather Matrix

by

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ABSTRACT.- Correlations were calculated between daily self-evaluated mood reports (4 reports/day) of 10 student subjects and 10 meteorological-geophysical variables over a 90-day period. The variables included mean and/or change measures of temperature, barometric pressure, relative humidity, sunshine hours, wind speeds and global geomagnetic activity. Multiple regression analyses indicated that the weather matrix used could account for not more than 35% of the mood variance on the day of the evaluation. Lag correlations over the previous week clearly indicated a greater number of significant correlations between mood reports and weather of the previous two days. The mean correlation coefficient was 0.27. In general, "lower moods" were associated with fewer sunshine hours, higher relative humidity, and smaller humidity variations than "higher moods". It was concluded that mood reports can show weak responsivity to antecedent weather fluctuations.

INTRODUCTION

A weak but significant relationship between human "mood" and weather changes is one of the oldest and most frequent reports in popular biometeorology. Although the statement seems intuitively obvious, the emperical verification of the relationship between weather and mood has been difficult and complex. The most fundamental difficulty has been concerned with the systematic and reliable measurement of "mood". Not only is the term poorly conceptualized by psychologists, but the interpretative meaning of mood shows marked time- and individual-dependent differences. Other problems are involved with the very real possibility that individuals respond in different ways to the same weather stimuli, depending upon the propensities of their individual autonomic nervous systems. Finally, a third major confounding variable is that many physiological changes correlated with the private experiences labeled as "mood" may occur hours to days following the actual weather stimuli.

Despite these complications, this study was initiated to determine if an individual's self-evaluation of mood could reliably reflect changes in weather either on the days of the mood reports or on previous days. The Dorland mood scale was selected as the report measurer since it has been shown to be relatively efficient for mood labeling.

METHOD

SUBJECTS.- Ten university students, five males and five females, 19 to 35 years of age, were selected as subjects. Participation was invited as options to other course work.

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PROCEDURE.- Each subject received a booklet that contained the Doorland mood rating scale (Dorland and Brinker, 1973). The scale ranged from 0 to 10 with descriptive words besides each number. For example, "6" on the scale was associated with the descriptors "mildly happy, pleasant, complacent", while "3" was associated with "unhappy, discontented, concerned". Subjects were instructed to rate their moods as accurately as possible four times per day: (1) within 1-h of awakening in the morning, (2) before lunch, (3) before dinner, and (4) before sleep. Consistency in time of the report was emphasized. Each subject was told separately to rate how he or she felt at the time of the evaluation, not how they "think" they felt 30 min before the rating. Explicit instructions were given not to fill the mood rating lists in retrospect if the evaluation period was missed. The final instruction was for the subjects to note any unusual occurrence that might heavily contribute to the evaluation, e.g., sickness, intoxication.

The subjects recorded their moods between 9 January to 8 April 1974. The mean moods for each day as well as the standard deviations for the four daily mood ratings were calculated; the latter measure was computed in order to detect any mood variability that might be masked by merely using the daily average. Days with missing data were used; however, all days had at least three mood ratings. No more than seven days for any given subject had less than four mood statements.

The following weather variables were selected to be correlated with the mood data: mean 24-h barometric pressure ($\overline{B}$), greatest change in barometric pressure/24-h (DB), greatest change in barometric pressure for any 2-h period/24-h (D2B), daily mean wind speed ($\overline{V}$), number of sunshine hours (SH), mean daily temperature ($\overline{T}$), range of daily temperature (DT), mean daily relative humidity ($\overline{RH}$), range of daily relative humidity (DH), and A-index level (AI), a measure of daily global geomagnetic activity.

Correlation matrices were calculated by computer between daily mean mood scores, daily standard deviations in mood scores, and the 10 meteorological-geophysical variables for days 1-30, 31-60, and 61-90 as well as for the entire period (days 1-90). The correlations were completed in partitions of 30 days in order to evaluate reliability, across analysis periods, of any mood-weather correlates that might occur, and to control for the seasonal shift in some variables, e.g., $\overline{T}$. Multiple regression analyses were conducted with 20 various combinations of both highly correlated ($r > 0.50$) and marginally correlated ($r < 0.30$) weather variables in order to determine those variables that might best explain any mood fluctuation. Finally, lag correlations were determined between mood scores and weather conditions for the previous 1 to 7 days. The latter correlations were completed to determine possible "mood change" delays following weather variations.

RESULTS

The mean mood evaluation scores for the 5 males over the 3 analysis periods (days 1-30, 31-60, and 61-90) were 6.0 ± 0.3, 6.0 ± 0.3, and 6.0 ± 0.3, respectively, while the 5 females averaged 5.6 ± 0.4, 5.5 ± 0.5, and 5.9 ± 0.6, respectively. These differences were not statistically significant ($F < 2$). The mean daily mood variation, i.e., score variations within the same day, for the male and female subjects averaged 0.7 ± 0.3 mood units.

Since there were 10 subjects and 10 weather variables, matrices of 100 correlation coefficients (Pearson-product "r") were generated for each of the 3 analysis periods. The three periods displayed 15, 4, and 7 significant ($p < 0.05$) correlations, respectively. Fifteen coefficients would be expected to be significant at this level by change alone (5/analysis period). Non-parametric analysis indicated that only the first analysis interval generated significant correlations more than chance expectancy ($\chi^2 = 21.00$, $df = 2$, $p < 0.01$). The matrix for the total 90-day

period generated only 10 significant correlations between any of the weather variables and reported mean moods. Five of the 10 subjects displayed significant ($p < 0.05$) correlations between mood and SH, D2B and $\overline{RH}$ during one of the analysis intervals. None of the subjects showed correlations between mood, and $\overline{V}$, $\overline{T}$, DH and AI. The remaining variables were correlated with the moods of not less than 1 but not more than 4 subjects. Analysis indicated, however, that this distribution of significant coefficients among subjects did not differ from a chance dispersion ($\chi^2 = 10.60$; df = 9; $p > 0.10$). Similarly, correlation matrices between daily mood standard deviations and the weather variables showed 8, 6, and 8 significant ($p < 0.05$) correlations across analysis periods, where 15 significant coefficients would be expected by chance alone. In order to test for possible within subject consistency for correlations between moods and weather variables across analysis periods, replications were checked. Only 1 of the 10 subjects showed significant correlations between mood and the same weather variable over two intervals. Scattergrams, generated to permit visual inspection of the data, indicated no gross deviation from linearity for the significant correlations.

Multiple regression analyses indicated that any combination of weather variables including those highly correlated within themselves, could not account for more than 35% ($r^2 = 0.35$) of the mean mood variability. Five of the subjects displayed significant "F" values ($F > 3.35$; df = 2, 27), for clusters of MT, MH, and MB on the day of the mood measurement over one of the 30 day analysis intervals. Correlations between $\overline{B}$ and $\overline{T}$ and $\overline{B}$ and $\overline{RH}$ for the 3 analysis intervals were ∓ 0.75 and -0.67; -0.47 and -0.73; and -0.46 and -0.67, respectively. Although $\overline{T}$ consistently showed the largest partial regression coefficients, the problem of multicollinearity attenuated any meaningful isolation of the control variable for this triad.

In addition to correlations on the day of the mood evaluation, lag correlations were calculated between mean mood (on day "n") and the weather variables for the previous 1 to 7 days ("n-1" to "n-7") for the total 90 day period. For the 10 subjects, 800 correlation coefficients were generated. A total of 114 coefficients were statistically significant beyond the 0.05 level (the number of coefficients expected to be significant due to chance at this level is equal to 40). A total of 69 coefficients were significant between the 0.05 level and the 0.01 level; another 45 were significant beyond the 0.01 level. Comparisons with expected values indicated that the number of criterion coefficients was statistically greater than chance ($\chi^2 = 8.39$; df = 1; $p < 0.01$). It was observed that the number of significant coefficients might have been artifactually inflated due to high inter-correlations between different weather variables redundantly correlating with mood. Consequently, on days where more than one significant correlation was found in either $\overline{T}$, $\overline{B}$, or $\overline{RH}$, only one of the significant correlations was counted from that triad. A similar treatment was used for DB and $\overline{V}$. With this control, 97 significant correlations still remained ($\chi^2 = 7.99$; df = 1; $p < 0.01$). The relative distribution of the total number of significant mood-weather correlations over the lag analysis, i.e., "n = 0" to "n = 7" is shown in Fig. 1. It can be seen that mood reports are maximally correlated with weather conditions during the previous two days. The average (mean) correlations for days "n-0", "n-1" and "n-2", and "n-3" to "n-7", were all 0.27.

The numbers of positive with respect to negative significant ($p < 0.05$) correlations occurring on the day of the mood measurements to two days before, are indicated in the parentheses (+/–, respectively) following each weather variable: $\overline{B}$ (4/3), DB (2/2), D2B (1/4), $\overline{V}$ (2/1), SH (6/0), $\overline{T}$ (4/4), DT (1/2), $\overline{RH}$ (2/7), DH (6/0), and AI (0/4). Analysis was not conducted because of the small sample size for each variable. However, it can be seen that increased mood scores were correlated more frequently with increased mean sunshine hours and lower humidity range, but with decreased mean humidity values.

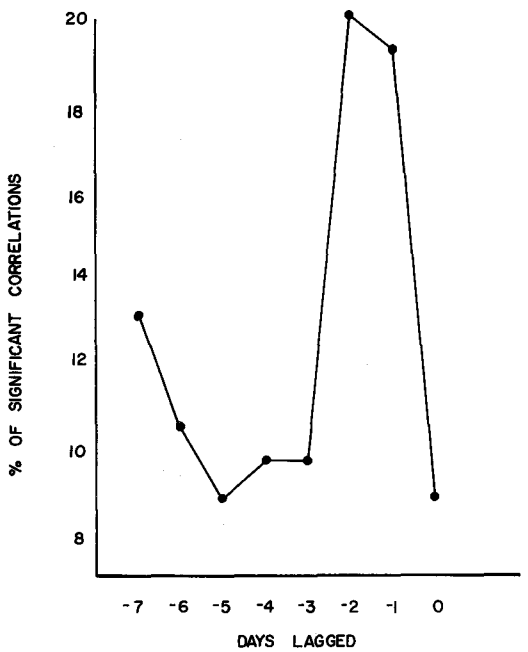

Fig. 1. Percent of total (n=114) significant correlations ($p < 0.05$) observed between the mean mood scores of 10 subjects and 10 weather variables on the day of any given measurement (Day 0) and the previous seven days (Days -1 to -7) over a 90-day analysis period.

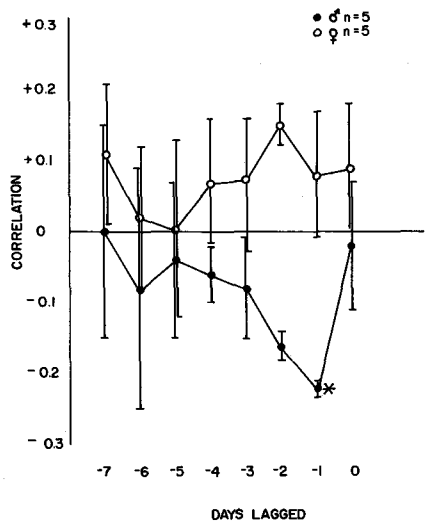

Fig. 2. Means and standard deviations (brackets) for correlation coefficients between mood scores and geomagnetic activity on the day of the mood (Day 0) and during the previous seven days (Days -1 to -7) over the 90-day analysis period for males (n=5) and females (n=5).

An interesting trend was noted between geomagnetic field variation and mood fluctuations. As can be seen in Fig. 2, a weak but persistent negative correlation existed during the 90-day analysis period for the mean mood of the male subjects and the geomagnetic conditions on the previous day. The negative correlations for 4/5 males for this day were significant ($p < 0.05$). Such a consistent relationship did not exist for the females, nor were similar relationships apparent with the other weather variables.

DISCUSSION

The present study has shown a weak sensitivity of self-evaluated mood reports to fluctuations in a selected weather matrix. It is clear, however, that the relationship existed at a marginally significant level since the average correlation coefficient was 0.27, independent of sign. In fact, even under the most optimal combinations of weather variables different portions of the weather matrix explained not more than 35% of the mean mood reflected by the Dorland scale and the analysis procedures. Sex differences, an ostensible source of mood variation, were not grossly apparent with this measurement scale. Since the process of "self-evaluation" is a covert and private verbal behaviour, it is quite likely that this response would be more rigorously under the stimulus control of situational and psychological factors. This limit does not preclude the possibility of a facilitory effect once particular verbal labels have been brought under the control of specific physiological changes.

One of the most interesting results noted in the present study was the relationship between mood reports and the weather matrices during the previous two days (Fig. 1). Although the average strength of the correlations was still 0.27, the number of weather variables correlating with mood during the following two days was markedly enhanced. Such data indicate that: (1) the weather conditions on the day of the mood evaluation were not the significant control variables for the effect, and (2) simple correlations between mood values and weather the same day may obscure a more intense relationship. The existence of this lag relation also attenuates the possibility of artifactual contributions from contemporaneous environmental cues at the time of the evaluation.

That considerable latencies can exist between the onset of a stimulus complex and the response of a homeostatic system, for both physical and organismic systems, is by no means unusual in biometeorology. One to two day response delays have been reported for geophysical-meteorological interactions (Beynon and Winstanley, 1969; Wilcox et al., 1973) and environmental-organismic correlations (Düll and Düll, 1935; Faust, 1972). Colds, a common correlate of more blatant meteorological changes, have been shown to be associated maximally with colder temperatures two to four days before the onset of the symptoms (Lidwell, Morgan and Williams, 1965).

In context of the present study, the results of Lidwell and his colleagues evoke an interesting speculation. Since mood may demonstrate shorter response latencies to weather than overt cold symptoms, it may be possible to discretely use weather-mediated mood changes as prodromal cues to cold susceptibilities. Such a supposition is not untenable considering the important role of the autonomic nervous system in both emotional and biometeorological profiles. Emotional behaviours, including "mood" and its various ramifications, are often the first signs of autonomic unstability. In fact, step-like changes in reinforcement schedules known to induce emotional behaviours, can be followed by autonomic-immune responses (Coover, Goldman and Levine, 1971; Persinger et al., 1974).

The small but consistent negative correlation between mood reports and geomagnetic activity on the previous day is interesting in light of other studies. The now famous (and controversial) work of Düll and Düll (1935) indicated an increase

in "nervous disturbances" one to two days after "magnetic storms". More recently, positive correlations between geomagnetic activity and psychiatric admissions were reported by Friedman, Becker and Bachman (1965). These data are compatible with the present findings since depression or "mood lows" frequently precede psychiatric behaviours. However, this statement must be taken with reservation since Pokorny and Mefferd (1966) did not find a geomagnetic effect with disturbed behaviour, even when the correlations were lagged.

As with most biometeorological studies, the role of individual differences was a constant source of effect variance. Nonetheless, a few general patterns were observed. Mood reports were positively correlated with the number of sunshine hours and humidity range but negatively correlated with mean humidity. One interpretation of this profile is that "higher" moods tended to occur more frequently on the first and second days after "sunny" days. Inversely, "lower" moods were preceded by cloudy days typified by high but consistent (small range) relative humidity. Although these patterns are commensurate with popular concepts, it must be remembered that the absolute mood range was quite small, i.e., about 0.5 units.

No doubt biometeorological relationships are complex, situation specific, and subject to unaccountable synergisms. However, assumptions of temporal homogeneity and uniform potency in data from any weather-related source, for the purposes of analysis, are beginning to appear questionable. Yet these assumptions are implicit in simple correlational analysis. Weather response profiles often show time-varying adjustment components, such as serially damped oscillations that are evoked by and follow step-like changes in weather demands. These patterns are characteristic of dynamic systems; blanket application of simple correlational methods can obscure the intensity of effect. The degree of weather effect is also a changing function of the response capacity of the system. Repeated presentations of the same intensity stimulus to a recently responsive system may not produce the same magnitude of change. Again, usual application of the correlation process would attenuate the effect. Perhaps it would be to our advantage as biometeorologists to concentrate more on mathematical models of analysis that can accommodate the quadratic-like patterns of weather-related responses, rather than excessive use of the simple correlation.

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REFERENCES

BEYNON, W.J.G. and WINSTANLEY, E.H. (1969): Geomagnetic disturbance and the troposphere. Nature (Lond.), 222: 1262-1263.

COOVER, G.D., GOLDMAN, L. and LEVINE, S. (1971): Plasma corticosterone increases produced by extinction of operant behavior in rats. Physiol. Behav., 6: 261-263.

DORLAND, J. and BRINKER, N. (1973): Fluctuations in human mood (a preliminary study). J. interdiscipl. Cycle Res., 4: 25-29.

DÜLL, T. and DÜLL, B. (1935): Zusammenhänge zwischen Störungen des Erdmagnetismus und Häufungen von Todesfällen. Dtsch. med. Wschr., 61: 95.

FAUST, V. (1972) : About weather sensitivity of healthy and psychic sick people. Unpublished paper, University Psychiatric Clinic, Basle, Switzerland.

FRIEDMAN, H., BECKER, R.O., and BACHMAN, C.H. (1965): Psychiatric ward behaviour and geophysical parameters. Nature (Lond.), 205: 1050-1052.

LIDWELL, O.M., MORGAN, R.W. and WILLIAMS, R.E.O. (1965): The epidemiology of the common cold. IV. The effect of weather. J. Hyg. (Lond.), 63: 427-439.

PERSINGER, M.A., OSSENKOPP, K.P., KAMAYA, V. and PEAR, J.J. (1974): Physiological changes associated with changing fixed ratio schedules in rats. Psych. Rep., 35: 847-850.

POKORNY, A.D. and MEFFERD, R.B. (1966): Geomagnetic fluctuations and disturbed behavior. J. nerv. men. Dis., 143: 140-151.

WILCOX, J.M., SCHERRER, P.H., SVALGAARD, L., ROBERTS, W.O. and OLSON, R.H. (1973) : Solar magnetic sector structure: relation to circulation of the earth's atmosphere. Science, 180: 185-186.